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Author(s)	MIYAZAKI, Bumpei, KAZATO, Takayuki, HAMAKAJI, Masaki, OBAMA, Kengo, KAITO, Kiyoyuki
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AN EMPIRICAL STUDY OF THE ROAD SURFACE MANAGEMENT CRITERIA FOR POROUS ASPHALT PAVEMENT OF EXPRESSWAY

Bumpei MIYAZAKI*, Takayuki KAZATO**, Masaki HAMAKAJI**
Kengo OBAMA* and Kiyoyuki KAITO*
OSAKA University*
West Nippon Expressway Company Limited **

***ABSTRACT*:** In recent years, expressway companies have adopted porous asphalt pavement in the surface layer of the pavement. As a result, with the conventional management criteria made for dense graded asphalt pavement, it is impossible to fully grasp the states of the pavement surface. In this study, the authors examine the validity of the current road surface management criteria and optimal road surface management criteria in terms of evaluation length and evaluation index. Firstly, the authors describe the deviation problem of results of the road surface condition survey and judgment of necessity for repair in practice. At that time, referring to the difference in the deterioration process between porous asphalt pavement and dense graded asphalt pavement, the authors point out the problems of the current road surface management criteria. In addition, the authors carry out empirical analysis that is based on the road surface condition survey data acquired from the expressway during service and study the optimal road surface management criteria. The analysis indicates that evaluation length should be shortened and the main evaluation index should be shifted to International Roughness Index from crack rate.

KEYWORDS: porous asphalt, Markov hazard model, IRI, crack, road surface condition survey

1. INTRODUCTION

Road pavement is used repeating partial repair, overlay and reconstruction in-service period. In order to manage a road efficiently, while states of the pavement surface needs to be evaluated exactly, it becomes important to set up optimal road surface management criteria. Also in the expressway, road surface management criteria are established using some indices (In the case of road surface; crack rate, amount of rutting and IRI (International Roughness Index)) about the performance which should be provided as expressway pavement, and it is already put in practical use.

In the expressway of our country, road surface condition survey is usually conducted once in 2 or 3 years, and the repair section has been selected by comparing the acquired data and the road surface management criteria. However, in recent years, as expressway companies adopts porous asphalt pavement in the surface layer of the pavement, it is impossible to fully grasp the states of the pavement surface with the conventional management criteria made for dense graded asphalt pavement. Especially, the localized damages such as potholes which are the typical damage forms of porous asphalt pavement are difficult to evaluate by the conventional management criteria. Since localized damage such as potholes with a cave-in and subsidence has big influence on a road user’s safety and running

Table1 Repair desired value of a pavement surface

Amount of Rutting	Ramp	Skid resistance coefficient	IRI	Crack rate
mm	mm	μ(80)	σ(mm)	%
25	20/30	0.25	3.5	20

comfortability, there are not few examples which repair in spite of not having reached a control limit in practice. In the maintenance of not only pavement but an infrastructure, judgment of each administrator in practice is important. Meanwhile, when it gazes at practice of pavement management, we should decide on new road surface management criteria which can support the administrator's judgment of necessity for repair and adapt to the actual condition of expressway of our country, and efforts to reduce the deviation with practice are required.

Under the above awareness of the issues, the authors examine the adequacy of the current road surface management criteria and optimal road surface management criteria. Chapter 2 explains about the difference of the deterioration process between porous asphalt pavement and dense graded asphalt pavement, and points out the problem of the current road surface management criteria from a viewpoint of the evaluation length and evaluation index. Chapter 3 carry out empirical analysis that is based on the road surface condition survey data acquired from the expressway during service.

2. EXAMINATION ABOUT THE OPTIMAL ROAD SURFACE MANAGEMENT CRITERIA

2.1 The actual condition of the maintenance of pavement of expressway

Since Meishin Expressway which is this country's first expressway was opened for traffic in 1963, dense graded asphalt pavement has mainly been adopted to the pavement surface of a domestic expressway. Dense graded asphalt pavement is cheap and the ease of the construction, and therefore it has

Table2 Actual value of crack rate just before the repairing

Roads	Crack rate(%)
A	8.21
B	11.07
C	8.45
Whole	9.05

also been applied in many sections. One of the typical damages of dense graded asphalt pavement is a wide range crack. Although the advance process of a crack is complicated and the deterioration mechanism is not fully solved, in general, the cause is considered that rain water permeates a pavement body from the crack which appeared in a certain range firstly, and the bearing power declines, it finally becomes a field-like crack in response to the influence of cyclic loading of the wheel. Administrators conduct road surface condition survey, and they will carry out emergency repair and overlay suitably, discerning the damaged condition of a road surface.

Table1 shows the desired value which shows that it is desirable to repair by the time each index reaches this value. This desired value is applied to all the expressway and ordinary toll roads of the whole country which each expressway company manages fundamentally. Particularly, in evaluation of the states of the pavement surface in our country, the crack rate is thought as important, and 100m of road sections unit is made into basic evaluation length. Moreover, the stage to which the crack rate acquired by the road surface condition survey reached to 20% is set as a control limit in many cases.

On the other hand, porous asphalt pavement is adopted as the pavement surface of expressway in recent years. Porous asphalt pavement is sets up void ratio more highly compared with dense graded asphalt pavement, and it has drainage system. For the reduction of the traffic accident at the time of rain and good cost performance, the range of use was expanded from judgment that it is suitable for user service. Since 1998, the use of porous asphalt mixture to asphalt pavement surface in expressway and exclusive motor-vehicle way became basic. However, after starting introduction of porous asphalt pavement genuinely, localized damage such as potholes came to appear here and there, and the cases which repeat repair for a short period of time increased in number. As one of the cause of this, the depth damage to the basis and the subgrade by the osmosis function and the fall of the exfoliation resistance below a basis is considered.

Of course, the administrator considers repair according to the repair desired value shown in table1. However, these desired values are established at the time which mainstream of the surface of expressway pavement was dense graded asphalt pavement. Therefore, in the present when the localized damage such as potholes occur frequently, the case that repair and emergency measures has been carried out even without reaching the control limit are not a few. Since the localized damage such as potholes which occur mostly in porous asphalt pavement is not accompanied by a wide range crack, and therefore the necessity of repair implementation is not will be carried out by the desired value, but by the judgment based on administrator's experience and intuition. Table 2 shows the actual value of crack rate just before the repairing (repair construction or improvement work) in the three roads of from A to C. In any road, the repair has carried out before reaching the control limit (20%). Since localized damage such as potholes with a cave-in and subsidence has big influence on a road user's safety and running comfortability, it is not a matter that can be ignored. In order to fill a gap with practice, that is, in order to carry out maintenance adapted to the actual condition of practice, we should decide on new road surface management criteria consistent with the administrator's judgment. In this study,

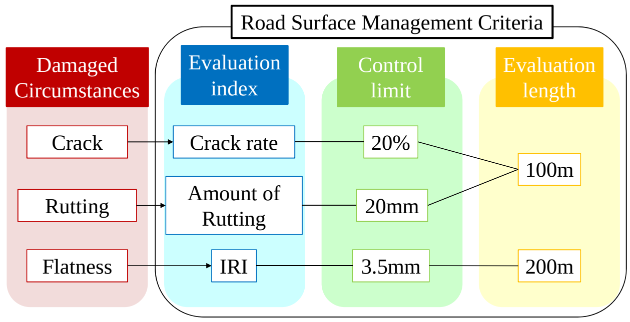


Figure1 Conceptual diagram of road surface management criteria

"road surface management criteria" is constituted by three things, the evaluation index, control limit and the evaluation length which is shown in figure1.

2.2 Determination of evaluation length

In examination of road surface management criteria, the determination of the evaluation length of pavement is an important issue. As the global Pavement Management System (PMS) for road pavement, HDM (Highway Design and Maintenance Standards Model) developed by the World Bank exists. The latest version of HDM-4 is mainly widely used as a supporting system of the road development and the maintenance plan in a developing country. In HDM-4, the basic unit of the evaluation length of the road is set as 1km. As the reason for this, in the developing country, the road surface condition survey is conducted manually and the state of the pavement is continuously bad over a long distance in many cases. However, these problems are being solved gradually, and therefore the problem that the required range of repair cannot grasp correctly sooner or later arises in evaluation of a 1km unit.

On the other hand, also in our country, various studies for PMS have so far been made. In our country, it is possible to acquire the road surface information on a 10m unit by the advancement of the performance of road surface condition survey car. By the road surface condition survey, evaluation indices about the crack, rutting and flatness, that is, crack

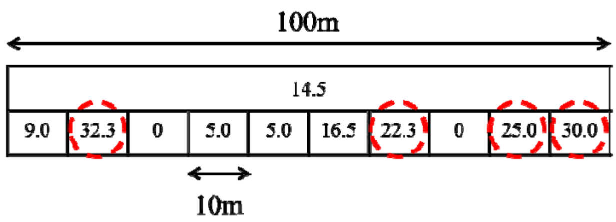


Figure2 The difference of result of road surface condition survey by the evaluation length

rate, amount of rutting and IRI are acquired. The evaluation index of crack rate and amount of rutting are 100m units and 10m units, and evaluation index of IRI is 200m units and 10m units.

Conventionally, in our country, 100m (200m) units were adopted as evaluation length in many cases. The most commonly expressed reason for this belief was the basic unit at the time of repairing is set to 100m in many cases. However, evaluation in a 100m unit is not enough to grasp the required range of repair like evaluation in a 1km unit, either. Moreover, when there are no abnormalities in a neighboring part even if road surface condition is locally inferior, a value is flatted, and the problem that it does not become so big a value as compared with a control limit arises when it evaluates in the 100m units. Figure2 shows an example of the difference of result of the road surface condition survey of the crack rate by the evaluation length. When evaluation length is 100m, the crack rate of the road section is 14.5%, but when evaluation length is 10m, many sections which exceed control limit are dotted with. This is the cause that the current evaluation with the data acquired by the road surface condition survey car differ from necessity judgment of repair implementation after visual inspection by the administrator each other. In the dense graded pavement, the same kinds of damage generate continuously, and therefore the evaluation in a 100m unit is not a problem. However, as mentioned above, the main damage forms in porous asphalt pavement is localized damage such as potholes, and therefore exact grasp of a damaged condition is not possible in evaluation in a 100m unit. When considering road surface management criteria suitable for porous asphalt pavement, it is required to make evaluation length into a 10m unit. Moreover, when evaluation length is changed by 200m and 10m also about IRI described in the following section, the numbers of parts exceeding a control limit differ greatly. Especially, the influence of local cave-in, subsidence and the level difference which is easy to generate on a bridge and the boundary of an earthwork part, which should be evaluated by IRI, will be underestimated by evaluation in 200m units. These facts have suggested the necessity for the examination about the validity of evaluation in 100m (200m) units.

2.3 Determination of evaluation index

As well as the determination of evaluation length, the determination of evaluation index is also an important issue. In road surface condition survey of our country, three indices (crack rate, the amount of rutting, and IRI) can be acquired simultaneously. As having mentioned above, localized damage such as potholes without a wide range crack is increasing as use of porous asphalt pavement become more mainstream in expressway pavement. Therefore, it is difficult to grasp road surface condition appropriately only by the conventional evaluation using the crack rate. Moreover, there is almost no example to which the amount of rutting reaches a control limit in the current expressway. Therefore, in this study, the authors focus on IRI which is a global indicator of flatness. Evaluation length of the IRI have been adopted 200m taking overseas case and management criteria of other index of Japan Highway Public Corporation at the time and construction lot of repair into consideration. However, when the result that the value of IRI in a certain 200m section is 3.5 (mm/m) was acquired by road surface condition survey, it was very difficult to judge the required range of repair from it. In recent years, since many cave-ins and subsidence are seen with porous asphalt pavement, acquisition of the information on a 10m unit has started also about IRI. IRI was introduced for the purpose of offering a more comfortable and safer road surface, and has been used as an index which measures a user's "degree of comfort" especially. However, while the damage form of a road surface changes a lot by introducing porous asphalt pavement, the importance of evaluation by IRI is increasing from the conventional evaluation which set weight to the crack rate.

In the case study shown in Chapter 3, the authors carry out the deterioration prediction based on the road surface condition survey data (crack rate, amount of rutting and IRI(International Roughness Index) acquired from the expressway during service and consider the difference in an expected life. A Markov deterioration hazard model is used for deterioration prediction. In that case, deterioration prediction is carried out to each database subdivided by a structural characteristic (embankment or bridge) or surface layer classification (dense graded asphalt pavement or porous asphalt pavement) and the authors show that prediction by IRI conforms to porous asphalt pavement. Moreover, in accordance with evaluation length, it verifies about the optimal road surface management criteria. In recent years, Bayesian estimation method is often used as estimation method of Markov deterioration hazard model. This is because an administrator's transcendental experience information is utilized as prior information and estimation accuracy can be secured, when accumulation of data is insufficient. However, in this case study, because the number of samples is rich in any data, estimation accuracy can be guaranteed enough even without using a Bayesian estimation method. Moreover, in this case study, the authors use not only the data by the evaluation length 100m, but the data by the evaluation length 10m. If we make a sample in the 10m units, the sample amount of 10 times is acquired as compared with 100m units for simple calculation. Therefore, if we conduct Bayesian estimation, calculation load becomes extremely large. From the above, the authors have adopted to the maximum likelihood estimation methods.

3. CASE STUDY

3.1 Outline of case study

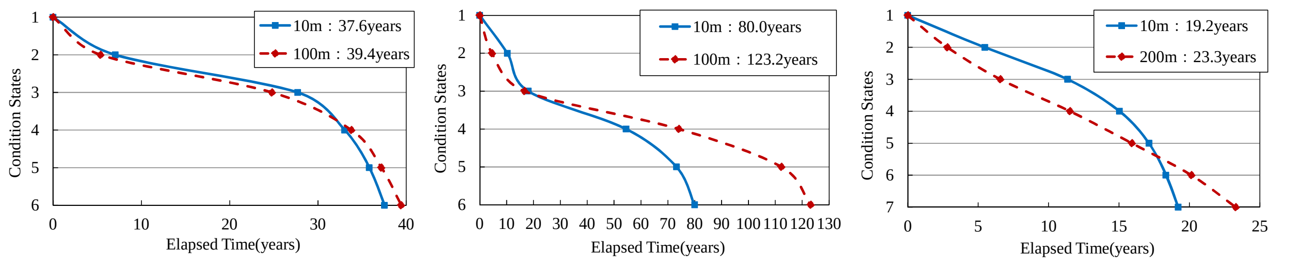
A Markov deterioration hazard model is applied to road surface condition survey data acquired from the expressway during service. The data used in this study is a vast quantity of data about three evaluation indices acquired by the road surface condition survey for the 23 roads. About each evaluation length, a crack rate and the amount of rutting are 10m and 100m units, and as for IRI, data was acquired by 10m and 200m units. Moreover, about the section where data was acquired in 10m units, data was also acquired in 100m units and both sections are mostly in agreement. The database of each evaluation length and evaluation index was subdivided four sub databases by the difference between structural characteristic (embankment or bridge) and surface layer classification (dense graded asphalt pavement or porous asphalt pavement). The sample used in a Markov deterioration hazard model was made by use the twice road surface condition survey data. For the data acquired, crack rate and the amount of rutting were evaluated in 6 steps, and IRI was evaluated in 7 steps. Table3 shows the definition of states according to evaluation index, and the number of samples of the after state for every sub database. The maximum value of states means the control limit. In this case study, the repair desired

Table3 Definition of states according to evaluation index, and the number of samples for every sub database

States	Crack rate Cr (%)	Number of samples/Evaluation length: 10m					Number of samples/Evaluation length: 100m				
		Embankment Dense graded	Embankment Porous	Bridge Dense graded	Bridge Porous	Sum total of a horizontal axis	Embankment Dense graded	Embankment Porous	Bridge Dense graded	Bridge Porous	Sum total of a horizontal axis
1	0≦Cr＜1	4,898	49,755	2,878	16,150	73,681	195	4,222	228	1,231	5,876
2	1≦Cr＜5	9,062	75,264	3,038	17,171	104,535	1,106	7,928	345	2,108	11,487
3	5≦Cr＜10	3,406	7,401	598	1,656	13,061	488	1,312	110	200	2,110
4	10≦Cr＜15	1,435	2,727	237	492	4,891	173	270	30	39	512
5	15≦Cr＜20	941	1,139	123	167	2,370	120	96	9	19	244
6	20≦Cr	3,301	1,932	260	274	5,767	298	97	24	22	441
Sum total of a vertical axis		23,043	138,218	7,134	35,910	204,305	2,380	13,925	746	3,619	20,670

States	Amount of rutting Ru (mm)	Number of samples/Evaluation length: 10m					Number of samples/Evaluation length: 100m				
		Embankment Dense graded	Embankment Porous	Bridge Dense graded	Bridge Porous	Sum total of a horizontal axis	Embankment Dense graded	Embankment Porous	Bridge Dense graded	Bridge Porous	Sum total of a horizontal axis
1	Ru＜7.5	866	16,656	799	5,099	23,420	413	3,800	96	1,132	5,441
2	7.5≦Ru＜10	778	10,040	502	3,089	14,409	987	5,911	280	1,493	8,671
3	10≦Ru＜15	942	6,511	350	1,964	9,767	737	2,194	102	514	3,547
4	15≦Ru＜20	166	565	29	124	884	92	69	16	26	203
5	20≦Ru＜25	30	60	1	18	109	2	9	2	0	13
6	25≦Ru	11	21	0	5	37	2	0	0	0	2
Sum total of a vertical axis		2,793	33,853	1,681	10,299	48,626	2,233	11,983	496	3,165	17,877

States	IRI (mm/m)	Number of samples/Evaluation length: 10m					Number of samples/Evaluation length: 200m				
		Embankment Dense graded	Embankment Porous	Bridge Dense graded	Bridge Porous	Sum total of a horizontal axis	Embankment Dense graded	Embankment Porous	Bridge Dense graded	Bridge Porous	Sum total of a horizontal axis
1	IRI＜1	4,876	38,276	746	6,586	50,484	114	728	12	170	1,024
2	1≦IRI＜1.5	7,590	46,366	1,212	9,343	64,511	639	2,343	167	231	3,380
3	1.5≦IRI＜2.0	4,934	23,075	1,027	7,096	36,132	730	2,865	454	544	4,593
4	2.0≦IRI＜2.5	2,357	10,113	653	3,900	17,023	402	1,408	266	548	2,624
5	2.5≦IRI＜3.0	1,210	4,750	354	2,061	8,375	175	534	102	375	1,186
6	3.0≦IRI＜3.5	679	2,749	242	1,372	5,042	66	167	50	127	410
7	3.5≦IRI	1,471	5,247	513	3,289	10,520	57	107	14	55	233
Sum total of a vertical axis		23,117	130,576	4,747	33,647	192,087	2,183	8,152	1,065	2,050	13,450



(a)crack rate (b)amount of rutting (c)IRI

Figure3 Expected deterioration path according to evaluation length

value shown in Table1 is defined as a control limit. This value is set up at the time when dense graded asphalt pavement is mainstream, and therefore please care about being premised that a crack rate and amount of rutting is evaluated in 100m units, and IRI is evaluated in 200m units. However, as a matter of course, table3 shows that the number of samples of evaluation length of 10m has the about 10-times amount of information compared with the number of samples of evaluation length of 100m. Moreover, samples of porous asphalt pavement more than the dense graded asphalt pavement in every evaluation length and evaluation index, and it can be seen that porous asphalt pavement has progressed as whole roads. Especially, there are many samples embankment and porous asphalt pavement, and number of samples of crack rate and IRI in the evaluation length 10m are more than 100,000 samples. Furthermore, there are very few samples to which deterioration progressed about the amount of rutting. This is due to slower deterioration of the rutting when compared to others, and therefore repair is carried out by the deterioration of crack and IRI before the deterioration progress of rutting, and the sample to which deterioration of rutting advanced is not acquired.

3.2 Estimation result by evaluation length

The figure3 shows the result of having estimated the expected deterioration path according to evaluation length about three evaluation indices, a crack rate, the amount of rutting, and IRI. The databases used for estimation are six databases of the sum total of the horizontal axis in table3. The years in the legend figure3 show the expected life until states reaches the maximum value (control limit). In every evaluation index, it turns out that an expected life becomes short as evaluation length becomes short. It has suggested a possibility that the expected life is overestimated, in the current evaluation length (100m, 200m). Moreover, although it is an unreal value about the expected life of rutting, this cause is the information bias that a sample to which deterioration advanced suffers a loss as section 3.1 described it. Furthermore, although the expected life of crack rate and IRI are also long as compared with a real life of pavement about 15~20years, an expected deterioration path is a strictly average curve, and please care about that the half (50%) of the object road section has reached at the control limit before an expected life.

Still more detailed examination is conducted to the crack rate which is the mainstream of the current evaluation index. Figure4 shows deterioration path according to the evaluation length and evaluation surface layer classification (about crack rate) in the sub database. The red curve in a figure means dense graded asphalt pavement and blue curve means porous asphalt pavement. Moreover, a solid line expresses evaluation by a 10m unit, and the dashed line expresses evaluation by a 100m unit. Also in any of dense graded asphalt pavement and porous asphalt pavement, for evaluation length 10m, expected life is shorter than in the case of evaluation length 100m. Moreover, by the case where evaluation length is 10m and 100m, while the difference of an expected life is 1.5 years in

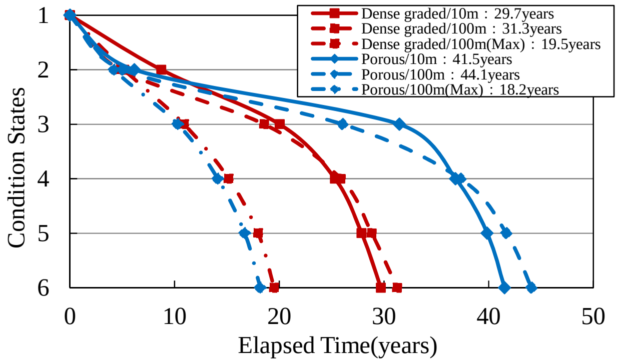


Figure4 Deterioration path according to the evaluation length and evaluation surface layer classification (about crack rate)

dense graded asphalt pavement, the difference has spread with 2.6 years in porous asphalt pavement. This is that the influence by evaluation length is small in the dense graded asphalt pavement which was conventional mainstream, and in the porous asphalt pavement which is main damage with the localized damage such as potholes, the influence by evaluation length has large.

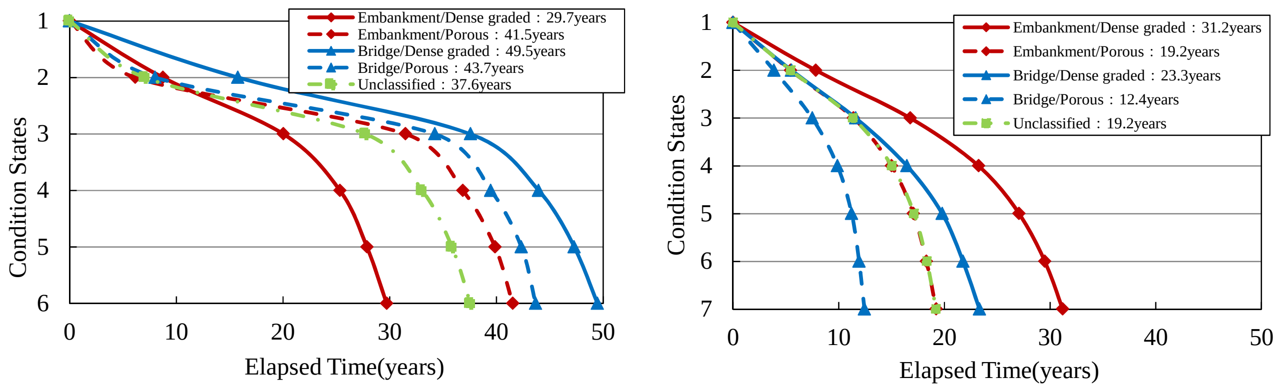
On the other hand, also in which evaluation length 10m and 100m, the expected life of porous asphalt pavement is long from dense graded asphalt pavement, and it differs from the practical feeling that deterioration of porous asphalt pavement is earlier than dense graded asphalt pavement. By conducting the evaluation of 10m units, it is true that localized big damage value which is a damage form peculiar to porous asphalt pavement was acquired as sample which can be used for estimation. But simultaneously, many healthy samples which damage has not generated were also acquired. Since all these samples are used when estimating, the influence of a localized big damage value on an estimation result is considered small.

Furthermore, in the figure, the curve of the alternate long and short dash line is show. This line is drawn based on the database at the time of evaluation using the "maximum value", while usually using “average value” as a representative value of 100m among the ten 10m sections in certain 100m. Of course, an expected life is short compared with the curve of the usual 10m evaluation and 100m evaluation, and it becomes about 20years. Moreover, when surface layer classification compares, the expected life of porous asphalt pavement is short in one year compared with dense graded asphalt pavement. From these, it can be said that the evaluation by the maximum value has high compatibility with practical feeling. In order to continue the evaluation of cracking rate in the future, the evaluation by the maximum value instead of evaluation by average value needs to be inquired. However, in this study, although the results that expected life is about 15~20 years consistent with the practice was acquired, the evaluation by the maximum value has a high possibility of underestimating an expected life. When considering the road surface management criteria which can support the administrator’s task appropriately, we have to examine the new index that usefulness is high, besides a crack rate.

3.3 Estimation result by evaluation index

Section 3.2 shows that an expected life may be overestimated in evaluation by the evaluation length of 100m (200m) and the influence by evaluation length become large in the present when that introduction of porous asphalt pavement progresses. Moreover, about the amount of rutting, the importance as the index is low because of the lateness of progress of deterioration by information bias. In this section, the authors set evaluation length to 10m, limit an evaluation index to a crack and IRI, and compare both. Figure5 shows the expected deterioration path based on the estimation result by the Markov deterioration hazard model of the each sub database of a crack and IRI. The solid line in a figure means dense graded asphalt pavement, and a dashed line means porous asphalt pavement. Moreover, a red curve expresses an embankment and the blue curve expresses the bridge part. Furthermore, a green alternate long and short dash line is drawn, without taking into consideration the structural characteristic and surface layer classification which was shown in figure3.

When a crack rate estimates as the left figure5 (a) showed, an expected life is short in an embankment compared with a bridge part. Moreover, when surface layer classification compares, the expected life of porous asphalt pavement is longer than the expected life of dense graded asphalt pavement in the embankment. On the other hand, the expected life of dense graded asphalt pavement is longer than the expected life of porous asphalt pavement in the bridge part. Of the four sub databases, an expected life of 29.7years is the shortest at an embankment and dense graded asphalt pavement. The whole average is 37.6 years and an expected life is longer than practical feeling. Moreover, when its attention is paid to the form of an expected deterioration path, the expected life from the state 2 to the state 3 is long, and the life after the state 3 is short. For verification of the actual data, focusing in Table3 again, the number of samples in state 2 is extremely large, and after that the number of samples is decreasing as soundness falls in the sub database of crack rate of evaluation length 10m. Furthermore, in the dense graded asphalt pavement, while the percentage of the sample which united the state 1 and state 2 is 61% in embankment and 83% in bridge part, in the porous asphalt pavement, the percentage of the sample which united the state 1 and state2 is over 90% and most samples to which states fell are not acquired when comparison by surface layer classification is conducted. That is, it can be said that the practical feeling that deterioration speed of porous asphalt pavement is earlier than dense graded asphalt pavement is not as



(a)crack rate　　　　(b)IRI

Figure5 Expected deterioration path according to the evaluation index and surface layer classification (embankment)

conformable as the states evaluation by the result of road surface condition survey of a crack rate. In dense graded asphalt pavement, many samples to which states fell are also acquired because repair is carried out in accordance with the conventional road surface management criteria. On the other hand, in porous asphalt pavement, since the localized damages with indispensable repair are occurring frequently although it is low as a crack rate, repair is carried out before reaching road surface management criteria, and therefore it is thought that the sample to which states fell is not acquired. For that reason, we can't acquire the results consistent with practice when estimation is conducted. It is the biggest problem of evaluation by crack rate that is pointed out in this study.

On the other hand, from Figure 5 (b), the expected life of a bridge part is shorter than an embankment when IRI estimates. In general, it is known that the value of IRI will become high in a bridge rather than an embankment from the influence of the joint in a bridge part. Moreover, it turns out that expected life of porous asphalt pavement is shorter than expected life of dense graded asphalt pavement in about ten years in both embankment and bridge when surface layer classification compares. The shortest expected life of bridge and porous asphalt pavement is 12.4years, the longest expected life of embankment and dense graded asphalt pavement is 31.2years, and the whole average expected life is in 19.2years. These calculated expected lives have very high compatibility with practice. The authors conducted same examination also about other evaluation length and evaluation index. However, what satisfy the following conditions that 1) the expected life of porous asphalt pavement is shorter than expected life of dense graded asphalt pavement, and 2) expected life is about 20 years, was not acquired except for IRI10m. These results show the importance of evaluation by the evaluation length of 10m and the evaluation index IRI. It is necessary to make a necessity judgment of repair, seeing those indices synthetically in the future.

4. CONCLUSION

In this study, the authors pointed out the problem of road surface management criteria using the mainstream evaluation length of 100m and an evaluation index crack rate in our country while introduction of porous asphalt pavement progressed to expressway pavement. Furthermore, the authors proposed using the evaluation length of 10m, and the evaluation index IRI as the alternative conventional road surface management criteria of an expressway, and described the application possibility from the estimation result based on real data. The estimation result shows that evaluation by the evaluation length of 10m and the evaluation index IRI consistent extremely practical feeling that administrators have won empirically. In the case of the necessity judgment for repair, and therefore it has suggested that it can become important one. About evaluation by the 10m unit of IRI, it is in the stage which each expressway company began to acquire data, and needs to do more detailed examination. A future subject is described below.

Firstly, the examination about a control limit is required. In this study, although the evaluation length and evaluation index which constitute road surface management criteria were examined, detailed examination about a control limit is not carried out. Rightly, it is necessary to set up a new control limit based on the value which was shown in Table2 when the control limit of 20% of a crack rate is considered not to be suitable in porous asphalt pavement. However, many dense graded asphalt pavement sections also still remained in the data used in the case study. Moreover, among the administrator, repair desired values shown in Table1, especially crack rate has spread extremely. From the above, after being premised on the control limit used from the former, the authors examine about evaluation length and an evaluation index. As the rate of porous asphalt pavement in the surface layer of road pavement of expressway increase in the future, it is necessary to determine the control limit adapted to porous asphalt pavement. Secondary, the detailed examination about the optimal evaluation length is required. The evaluation length of expressway pavement and the length by which repair is carried out in practice are not necessarily same. When advanced deterioration is observed in a certain road section, there are not few examples which repair also about the section of the neighborhood which has not been reached to the control limit at once from a viewpoint of expense. Moreover, when the construction environment in practice is taken into consideration, even if it repairs only several 10m with intense damage, it is very difficult to build a good road surface. In the practice, it becomes securable flatness only after constructing a certain fixed extension. In this study, the optimal evaluation length from a viewpoint of grasp of road surface condition was examined. However, we must examine from various related aspect such as life cycle expense and the characteristic of construction in practice. Finally, it is true that knowledge acquired from the case study shows that the estimation result based on the database of IRI10m consistent extremely practical feeling, however it is not expressed that relation with the generating process of the localized damage such as potholes and progress of deterioration of IRI. In order to adopt evaluation by IRI positively, it is necessary to verify about the relationship of IRI and road surface localized damage.

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